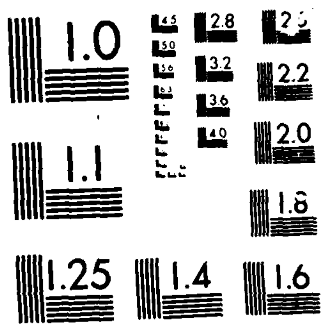
AD-A165 635 PERFORMANCE ANAYSIS OF DIGITAL LOS LINK MORMOND HILL-LATHERON UK (M0672)(U) DEFENSE COMMUNICATIONS ENGINEERING CENTER RESTON VA N J SOROVACU SEP 85 1/1

UNCLASSIFIED DCEC-TR-7-83 F/G 17/2 NL



MICROCOPY RESOLUTION TEST CHART

AD-A165 635

TR 7-83

DEFENSE COMMUNICATIONS ENGINEERING CENTER

TECHNICAL REPORT NO. 7-83

PERFORMANCE ANALYSIS OF DIGITAL LOS LINK MORMOND HILL-LATHERON, UK (MO672)

SEPTEMBER 1983

Approved for Public Release; Distribution Unlimited

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER DCEC TR 7-83	2. GOVT ACCESSION NO. AD-A165635	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Performance Analysis of Digital LOS Link Mormond Hill-Latheron, UK (M0672)		5. TYPE OF REPORT & PERIOD COVERED Technical Report
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Nicholas J. Sorovacu		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Defense Communications Engineering Center Transmission Engineering Directorate 1860 Wiehle Avenue Reston, VA 22090		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS N/A
11. CONTROLLING OFFICE NAME AND ADDRESS (Same as 9)		12. REPORT DATE September 1983
		13. NUMBER OF PAGES 20
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) N/A		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A

16. DISTRIBUTION STATEMENT (of this Report)

A. Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

N/A

18. SUPPLEMENTARY NOTES

Review relevance 5 years from submission date.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Link Performance
Path Profile
Digital Upgrade
Fading
Ducting
Diversity Mode

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The U.S. Navy has been tasked to upgrade link M0672, Mormond Hill-Latheron, UK for digital operations. Technical guidance was requested from DCEC to analyze link performance expected of the digital configuration and to assess the potential of using DIDICOM units in conjunction with quad diversity.

TECHNICAL REPORT NO. 7-83

PERFORMANCE ANALYIS OF DIGITAL LOS LINK

MORMOND HILL-LATHERON, UK

SEPTEMBER 1983

Prepared by:

- Nicholas J. Sorovacu

Technical Content Approved:

D. O. Schultz

D. O. SCHULTZ
Acting Deputy Director for
Transmission Engineering

Approved for Release:

Daniel M. Jones

DANIEL M. JONES
Acting Principal Deputy
Director

FOREWORD

The Defense Communications Engineering Center Technical Reports (TR's) are published to inform interested members of the defense community regarding technical activities of the Center, completed and in progress. They are intended to stimulate thinking, encourage information exchange, and provide guidance for related planning and research. They are not an integral part of the DoD PPBS cycle and should not be interpreted as a source of program guidance.

Comments or technical inquiries concerning this document are welcome, and should be directed to:

Director
Defense Communications Engineering Center
1860 Wiehle Avenue
Reston, Virginia 22090

EXECUTIVE SUMMARY

This Technical Report (TR) contains the performance analysis of and recommendations for digital implementation of the DCS microwave link M0672 between Mormond Hill and Latheron, UK scheduled for FY 84.

The expected performance is assessed in terms of path clearance for K-factor values ranging between 0.67 and 1.33, and of the impact of various types of fading on performance of this link. Eight viable link configuration alternatives are derived through various combinations of dual space or frequency diversity, 6.3 Mb/s (4 digroups) or 12.6 Mb/s (8 digroups) data rates, and two antenna sizes (10 and 12 ft.). All link configurations use standard DRAMA radio equipment in the 8 GHz RF spectrum and circular waveguides.

An optimum link configuration is recommended that consists of reutilized 12 foot parabolic antennas (spaced 26 feet apart) in a dual space-diversity configuration accommodating a 6.3 Mb/s data rate capacity. Long term RSL/ICN and meteorological data collection is recommended to verify adequacy of the path clearance during subrefractive propagation conditions. An alternate repeater site location - Scaraben - is suggested to improve the path clearance.

Compliance with DCS performance standards of the recommended link configuration based on dual space diversity eliminates the need for DIDICOM units in conjunction with quad diversity.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

I. INTRODUCTION

The purpose of this analysis is to assess the performance of a digitized LOS link M0672 between Mormond Hill and Latheron, northern United Kingdom. Technical guidance and recommendations are provided for reconfiguration of this link for optimum performance in compliance with DCS standards.

COMNAVTELCOM, Washington, DC requested DCEC to perform a detailed path analysis for the digital reconfiguration of the subject link to accommodate up to eight digroups at an RF frequency of 8 GHz.

A summary of the correspondence related to this effort follows in section II. The analysis for link performance is presented in section III, followed by recommendations for an optimum link configuration in section IV. Conclusions of the analysis are given in section V.

II. BACKGROUND

NAVELEXCEN, Portsmouth, VA indicated in their message of February 1983 (111210Z Feb 83) that a preliminary path analysis shows "that neither frequency nor space diversity by itself, will work, therefore, a quad diversity will be required." It concluded by suggesting that the link be considered for potential use of the Digital Diversity Combiner (DIDICOM) unit which is also planned for the DCS link between Swingate, UK and Houtem, Belgium.

COMNAVTELCOM (message 221804Z Feb 83) requests that DCEC perform a detailed path analysis in order to determine the need for quad diversity and DIDICOM units on the subject digital LOS link. It further requests NAVELEXCEN to provide initial path analysis, and NAVCOMMSTA Thurso to furnish recent TEP data in support of the DCEC analysis.

A preliminary link analysis and path profile of the Latheron-Mormond Hill link was received from NAVELEXCEN in their correspondence of 8 March 1983.

NAVCOMMSTA Thurso's correspondence of 24 March 1983 forwarded daily plots of average ICN levels measured on the LOS path from Thurso to Edzell between September 1982 through February 1983. Note that both Mormond Hill and Latheron are unmanned sites, and that the LOS link between them is one of the four LOS links connecting Thurso to Edzell.

A summary of our preliminary link analysis was forwarded in a message on 13 April (message 132107Z Apr 83). The results show that neither DIDICOM units nor quad diversity will be required to meet DCS standards. A dual space diversity configuration is recommended for optimum performance. Additional data are needed to assess the path clearance during abnormal propagation conditions.

III. LINK PERFORMANCE ANALYSIS

The performance of the Mormond Hill-Latheron, UK link upgraded to digital operation is evaluated in terms of link availability and channel quality criteria described in reference [1], design procedures identified in reference [2], and similarities in performance analysis depicted in reference [3].

1. PATH PROFILES

A review of the most recent publications on weather conditions controlling propagation on the subject LOS link concluded with very little information on the refractivity gradient data (dN/dh). The yearly K factor distribution is estimated from data of reference [4] to vary from values of K= 0.67, to values of K=1.33. Additional data are needed to define the yearly distribution of the K factor.

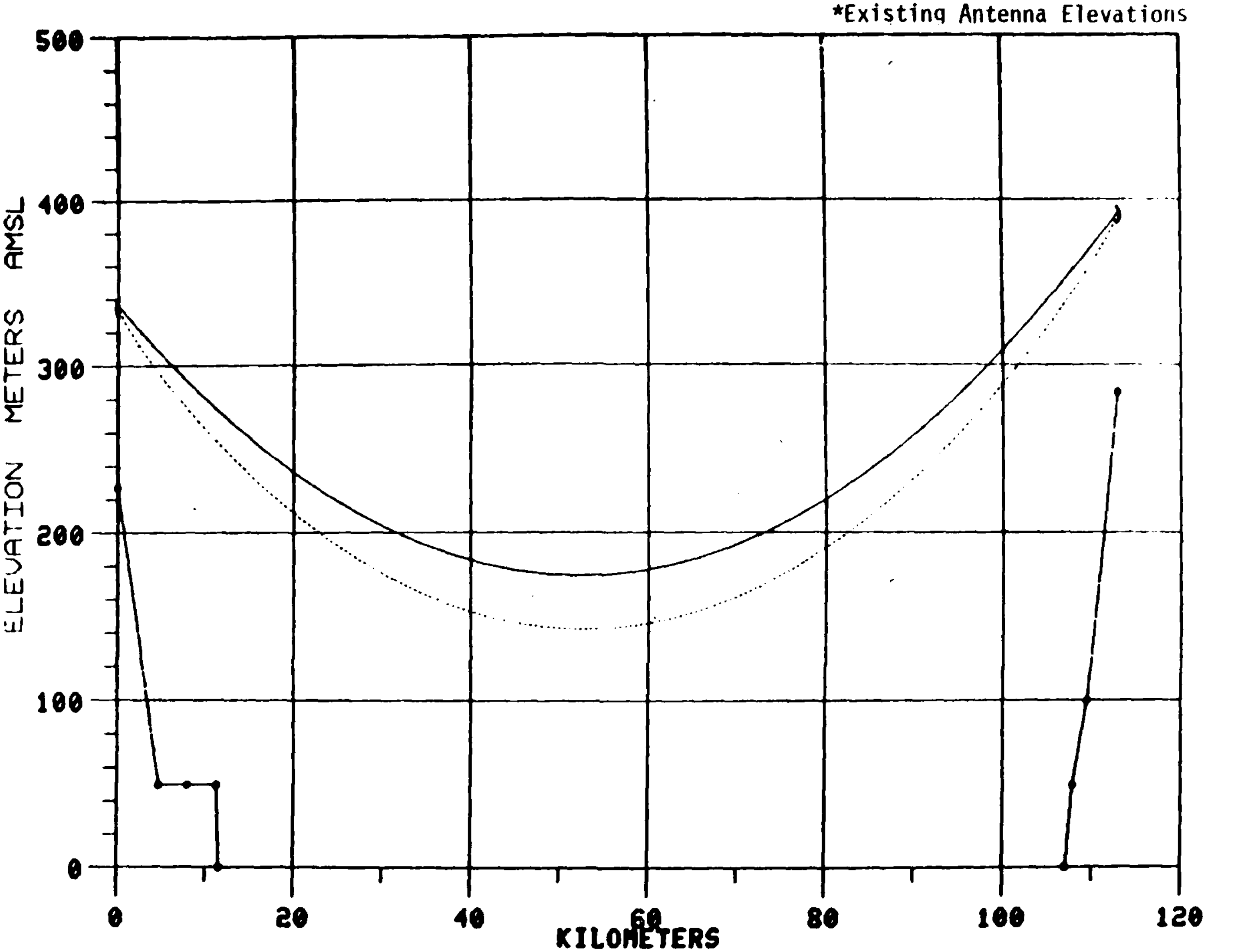
The path profiles of the Mormond Hill-Latheron LOS link using existing antenna tower heights are shown for K=1.33, 1.0 F_1 and K=0.67, 0.3 F_1 in Figures 1 and 2 respectively. Note the path blockage for a subrefractive K factor (K << 1). Figure 3 shows that an adequate path clearance for K=0.67, 0.3 F_1 is obtained by raising the height of the antenna tower at each end location by 19 meters (approximately 63 feet), which is not a very cost-effective alternative since the height of existing antenna towers is over 107 meters (350 ft).

2. NORMAL FADING EFFECTS

As described in the analysis of reference [3], normal fading includes the following: (1) flat or frequency selective multipath, (2) atmospheric absorption, and (3) fog. The effects of multipath fading are considered in this section; the other effects cause negligible degradation to the link performance.

a. Multipath Flat Fading. The LOS link design of reference [2] allocates a link margin (M_L) for flat fading of $M_L = 9 \log D + 18$ dB (where D is the path length in km) in conjunction with a path clearance criteria of K=0.67 and F_1=0.3. This results in a fade margin of 36.5 dB, which is further increased by a 3.0 dB correction factor to account for terrain (smooth), annual average temperature (cool), and humidity (coastal). An average value of 43.9 dB was measured for the fade margin of this link during August 1976, as reported in the TEP of reference [5]. No other data are onhand to support such a value.

b. Multipath Frequency Selective Fading. A computer program was developed in support of the multipath frequency selective fading (FSF) analysis. A description of the FSF program is presented in Appendix B of reference [3]. The results of this program predicts negligible effects of FSF on performance of the subject link when operating at a data rate of 6.3 Mb/s, and about 1 - 2 dB degradation in the signal-to-noise ratio at 12.6 Mb/s.



SITE: MORMOND HILL
GND ELEV: 227.0 M AMSL
*ANT HT:109.0 M AGL

PATH LENGTH: 112.9 KM
K: 1.33 FRQ: 8.200 GHZ
FRESNEL CLEARANCE: 1.0

SITE: LATHERON
GND ELEV: 284.0 M AMSL
*ANT HT:107.0 M AGL

Figure 1. Path Profile for Link M0672
($K=1.33$, $1.0\ F_1$)

DATE: 10-MAR-83

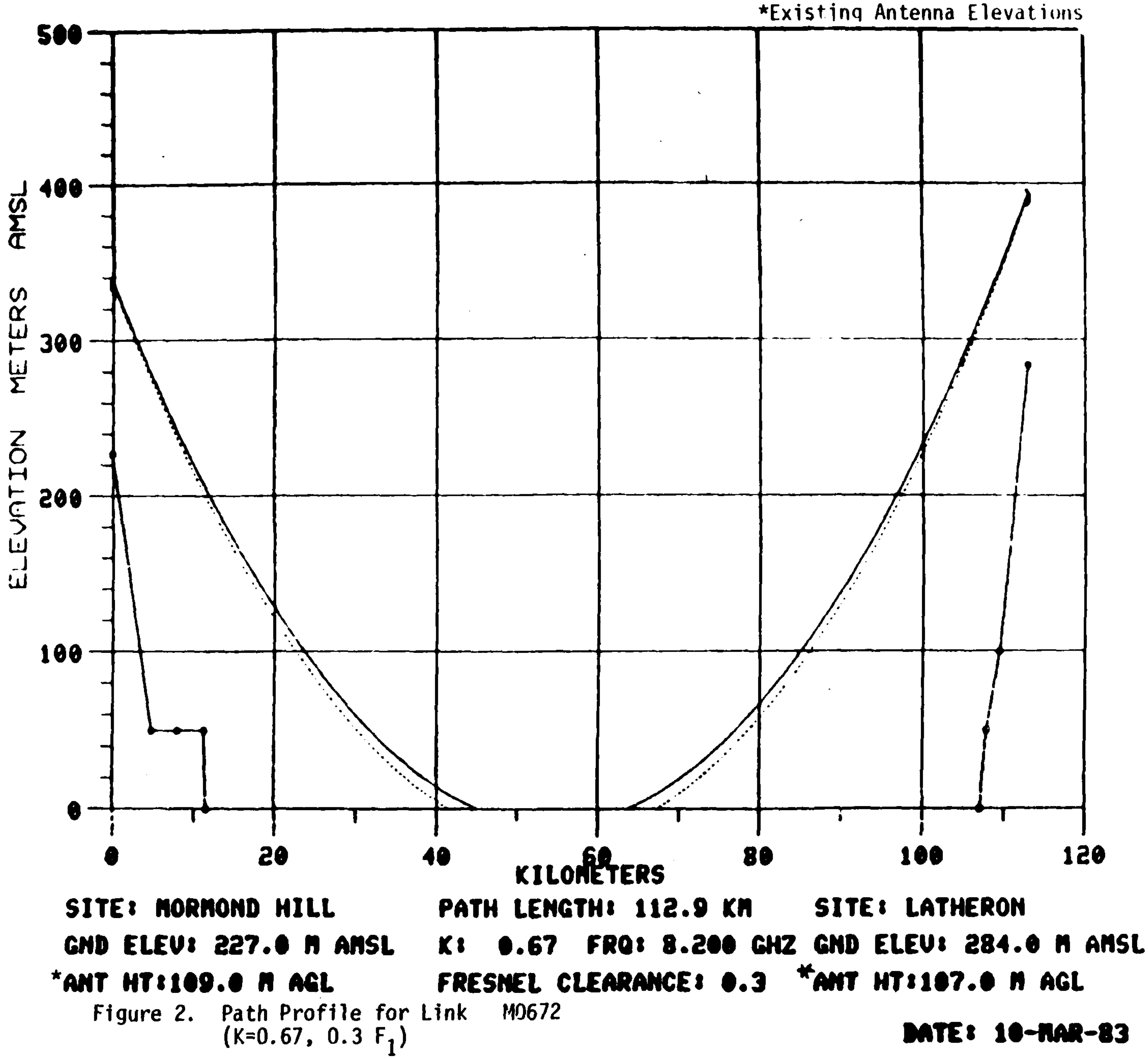
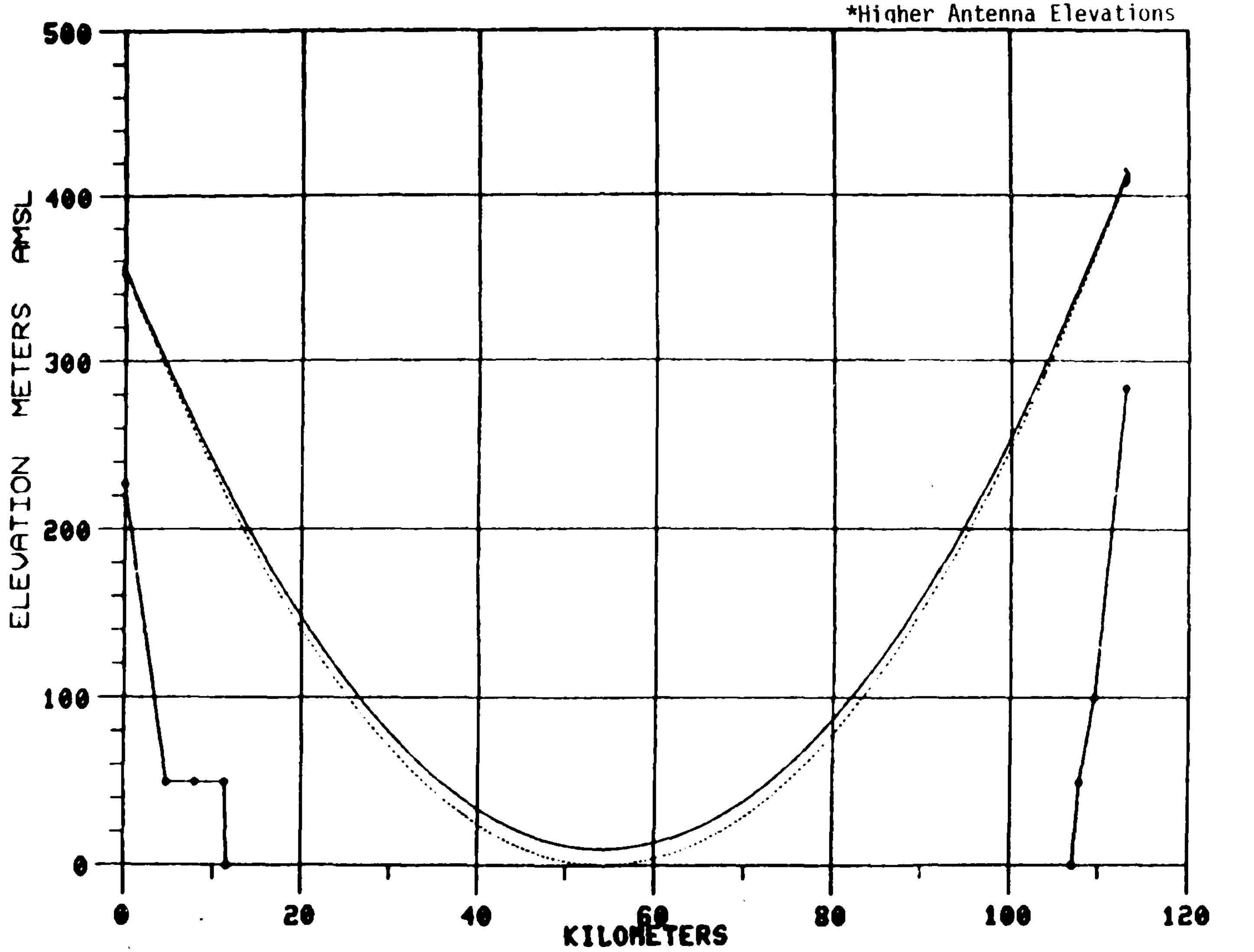


Figure 2. Path Profile for Link M0672
($K=0.67$, $0.3\ F_1$)



SITE: MORMOND HILL
GND ELEV: 227.0 M AMSL
* ANT HT:128.0 M AGL

PATH LENGTH: 112.9 KM
K: 0.67 FRQ: 8.200 GHZ
FRESNEL CLEARANCE: 0.3

SITE: LATHERON
GND ELEV: 284.0 M AMSL
*ANT HT:128.0 M AGL

DATE: 14-FEB-83

Figure 3. Path Profile for Link M0672 with Raised Antenna Tower ($K=0.67$, $0.3\ F_1$)

3. ABNORMAL FADING EFFECTS

The types of abnormal fading effects considered for this link include: (1) subrefractive ($K \ll 1$), (2) superrefractive ($K \gg 1$), and (3) ducting. The fourth type, rain attenuation, is negligible.

a. Subrefractive Fading. The path profile of Figure 2 shows that the existing subject LOS link is partially/totally blocked during subrefractive fading conditions (i.e., $K \leq 2/3$). Figure 4 further illustrates such performance degradation affecting both the upper and lower antenna beams of the existing link configuration. No test data are available to quantify the frequency, depth, and duration of service interruptions caused by the subrefractive fading effects. Note that negligible improvement would be gained through utilization of quad diversity.

b. Superrefractive Fading. The superrefractive fading conditions occur during variations in the K factor toward the maximum values ($K \geq 1.33$) and multiple Fresnel zones (F of 1,2, ... n). The maximum separation of antennas configured for space diversity is controlled by the "roller coaster" effects on received signal levels (RSL's) that are characteristic of superrefractive fading conditions. Very little performance improvement is attained from a space diversity (SD) configuration that has the two antennas located too far apart (i.e., both RSL's will bottomout at the same instant). The antenna separation of the existing link is 49 meters (162 ft). This is shown in Figure 4. The RSL data collected at Latheron during August 1976 and reported in reference [5] show negligible SD improvements, thus indicating an excessive antenna separation. No other test data are available to further assess the impact of superrefractive fading on link performance.

c. Ducting. Surface ducting is characteristic of coastal areas, occurring during superrefractive conditions ($K \gg 1$) caused by temperature/humidity inversions predominant during spring and fall. Such a phenomenon is illustrated in Figure 4. Note that the signal path is well above surface ducting, thus causing minimum link performance degradation. No test data are available to evaluate adverse effects of ducting on this link.

4. SUMMARY OF EXPECTED PERFORMANCE DEGRADATION

Table I presents a summary of the performance degradation expected from various fading effects. Note that the most important degradation is expected to be the path blockage (or "earth bulge") caused by an inadequate path clearance for $K \leq 0.67$ and $0.3\ F_1$. Additional data are needed to make a decision on relocating one of the sites to attain an adequate path clearance.

5. ALTERNATIVES FOR LINK CONFIGURATION

Design trade-offs among various components affecting link performance were considered in order to optimize performance at minimum cost. Eight alternatives for the digital configuration of the LOS link between Mormond Hill-Latheron are depicted in Table II. Each one of them, using standard DRAMA radio equipment, will satisfy the DCS performance criteria described in

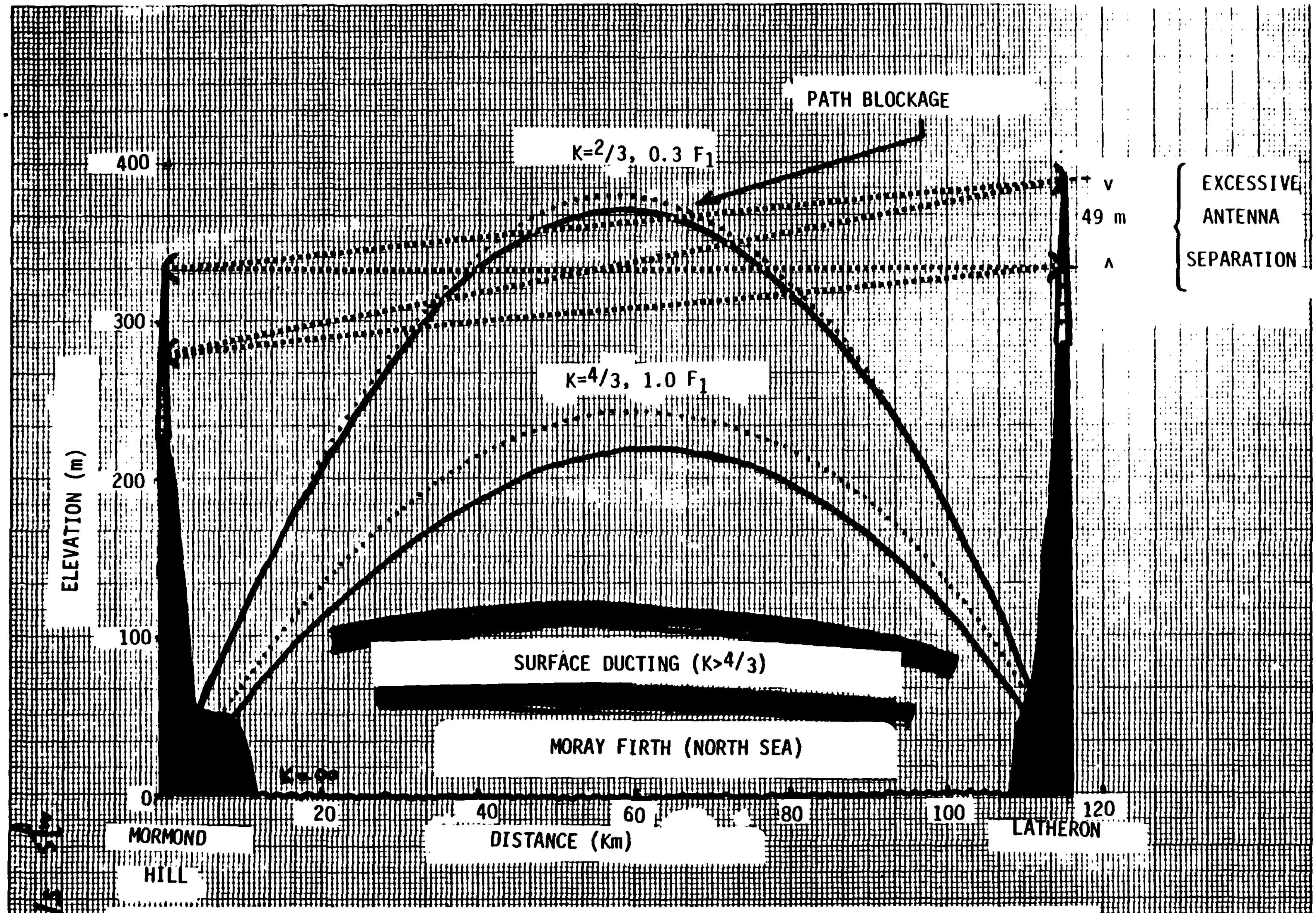


Figure 4. Problem Areas of DCS Link M0672

TABLE I. EXPECTED PERFORMANCE DEGRADATION CAUSED BY FADING, MORMOND HILL-LATHERON, UK DIGITAL LOS LINK

FADING	IMPACT	CORRECTIVE ACTIONS	REMARKS
A. NORMAL			
1. Multipath Flat	35-40 dB	Provide Enough Link Margin	TEP: Link Margin Equals 44 dB
2. Frequency Selective	1-2 dB	Use Lower Data Rate	--
3. Others	Negligible	--	Includes Atmospheric Absorption and Fog
B. ABNORMAL			
1. Subrefractive	Path Blockage	Relocate Site(s)	Need Additional Data
2. Superrefractive	Roller Coaster Effects	Move Antenna Closer	Improve Space Diversity Gains
3. Ducting	Negligible	--	Mostly Surface Ducting
4. Rain Attenuation	Negligible	--	--

TABLE II. ALTERNATIVES FOR DIGITAL LOS LINK CONFIGURATION, MORMOND HILL-LATHERON, UK

Diversity Type	Data Rate (Mb/s)	Antenna Size (m/ft.)	Fade Margin (dB)(Note 2)
Dual Space (Note 3)	6.3	3.05/10 3.66/12	42.7 45.9 (Note 4)
	12.6	3.05/10 3.66/12	39.7 42.9
Dual Frequency	6.3	3.05/10 3.66/12	43.0 46.2
	12.6	3.05/10 3.66/12	40.0 43.2

NOTES:

1. All configurations use DRAMA radios specified at 8 GHz baseband frequency, 33 dBm transmitter power, 10 dB receiver noise figure, and low loss circular waveguides.

2. A fade margin of 39.5 dB is required to meet DCS standards (reference [2]).

3. Antenna separation is 8 m (26 ft).

4. Recommended link configuration.

reference [2]. Note that about the same performance is obtained from either a dual-space or dual-frequency diversity configuration, and that a one-size-larger antenna is required to retain an equivalent fade margin when doubling the data rate (6.3 to 12.6 Mb/s). An example of link performance calculations using the computer program of reference [2] is given in Figure 5.

***** UNCLASSIFIED

MORMON HILL TO LATHERON

FREQUENCY IN GHZ =	8.0000E+00
PATH LENGTH IN KILOMETERS =	1.1290E+02
XMTR ANTENNA HEIGHT ABOVE GROUND IN METERS =	1.0900E+02
XMTR HORIZONTAL XMSN LINE LENGTH IN METERS =	1.0000E+01
TOTAL XMTR XMSN LINE LENGTH IN METERS =	1.1900E+02
XMSN LINE TYPE(RECT=1,ELLIP=2,CIRC=3,COAX=4) IS	3
XMSN LINE LOSS FACTOR IN DB/METER =	2.2000E-02
TOTAL XMTR XMSN LINE LOSS IN DB =	2.6180E+00
RCVR ANTENNA HEIGHT ABOVE GROUND IN METERS =	1.0700E+02
RCVR HORIZONTAL XMSN XMSN LINE LENGTH IN METERS =	1.0000E+01
TOTAL RCVR XMSN LINE LENGTH IN METERS =	1.1700E+02
TOTAL RCVR XMSN LINE LOSS IN DB =	2.5740E+00
LOWER RCVR ANTENNA HEIGHT ABOVE GROUND IN METERS =	9.9000E+01
MEDIAN LOS FREE SPACE LOSS IN DB =	1.5162E+02
TOTAL LOSSES(XMTR & UPPER RCVR ANTENNAS) IN DB =	1.5681E+02
TRANSMITTER POWER IN DBM =	3.3000E+01
RECEIVER NOISE FIGURE IN DB =	1.0000E+01
RECEIVER NOISE DENSITY IN DBM/HZ =	-1.6400E+02
MODULATION BIT RATE IN BITS/SEC =	6.3000E+06
REQUIRED EB/NO IN DB FOR BER = 10**-4 IS	1.4000E+01
THRESHOLD FOR FADED RSL IN DBM =	-8.2007E+01
REQUIRED FADE MARGIN IN DB =	3.6474E+01
FADE MARGIN CORRECTION FACTOR IN DB =	3.0000E+00
CORRECTED FADE MARGIN IN DB =	3.9474E+01
TOTAL LINK MARGIN IN DB =	4.5474E+01
TOTAL ANTENNA GAINS(BOTH ENDS) IN DB =	8.7275E+01
CALCULATED ANTENNA DIAMETER IN METERS =	2.2784E+00
ANTENNA DIAMETER CORRECTION FACTOR =	2
PARABOLIC ANTENNA DIAMETER USED IN METERS =	3.66
SINGLE ANTENNA GAIN IN DBI =	4.6851E+01
UNFADED RSL IN DBM =	-3.0105E+01
ACTUAL FADE MARGIN IN DB =	4.5902E+01
AVERAGE YEARLY TEMPERATURE IN DEGREES F =	55.00
YEARLY FRACTION THAT IS FADING SEASON IS	2.5000E-01
TERRAIN ROUGHNESS FACTOR(SMOOTH=6,AVERAGE=15,ROUGH=42) IN METERS IS	6.0
CLIMATE FACTOR(HUMID=2,AVG=1,DRY=0.5) IS	2.0
CLIMATE AND TERRAIN FACTOR =	6.5819E+00
DIVERSITY SWITCH FACTOR =	2.5119E+00
RCVR ANTENNA SEPARATION OR EQUIVALENT IN METERS =	8.0000E+00
DIVERSITY FACTOR IS	6.8896E+02
PROBABILITY RSL IS BELOW THRESHOLD PO =	1.9834E-06
Z(MF,D,F) FACTOR =	3.6900E+00
PROB FADE OUTAGE 5 TO 60 SEC =	7.3190E-06

Figure 5. Example of Link Performance Calculations

IV. RECOMMENDED LINK CONFIGURATION

The dual space diversity (SD) configuration with 3.66 meter (12 ft) antennas and operation at 6.3 Mb/s is recommended for digital implementation of the subject LOS link. Dual space diversity (SD) is favored in lieu of the dual frequency diversity (FD) to allow for potential future growth in capacity of this link that may result from reconfiguration in DCS connectivity in support of Thurso. An adaptive equalizer might be needed if the data rate capacity of the subject link were increased to 26 Mb/s. Various tests run so far favor utilization of an adaptive equalizer on SD rather than FD links.

Assuming adequate path clearance, the existing lower antenna will have to be raised to within 8 meters (26 ft) of the upper antenna. The vertical spacing between the antennas was selected to optimize SD gains and to minimize the adverse effects of the water-reflection multipath fading. Further details are provided on pages 58-59 of reference [6].

Furthermore, the antennas at each end location will be connected to the DRAMA radio equipment via new circular waveguides run to reduce the transmission losses of the long waveguide runs.

Since no data available for this analysis could support and validate the assumption of path blockage during subrefractive propagation conditions, the author recommends that a long-term effort (9 to 12 months) be initiated to collect RSL/ICN and meteorological data in order to finalize the configuration and, possibly, the location of the subject link sites. If excessive performance degradation or outages are caused by the "earth bulge," a viable alternative would be to relocate the unmanned repeater site of Latheron to a new hilly location about 16 km (10 miles) south-west called Scaraben. The path profile for the new Mormond Hill-Scaraben link is shown in Figure 6. Note that a short tower (about 20 meter/66 ft) would provide an adequate path clearance for subrefractive K factors. The above link performance analysis and the recommendations will remain the same.

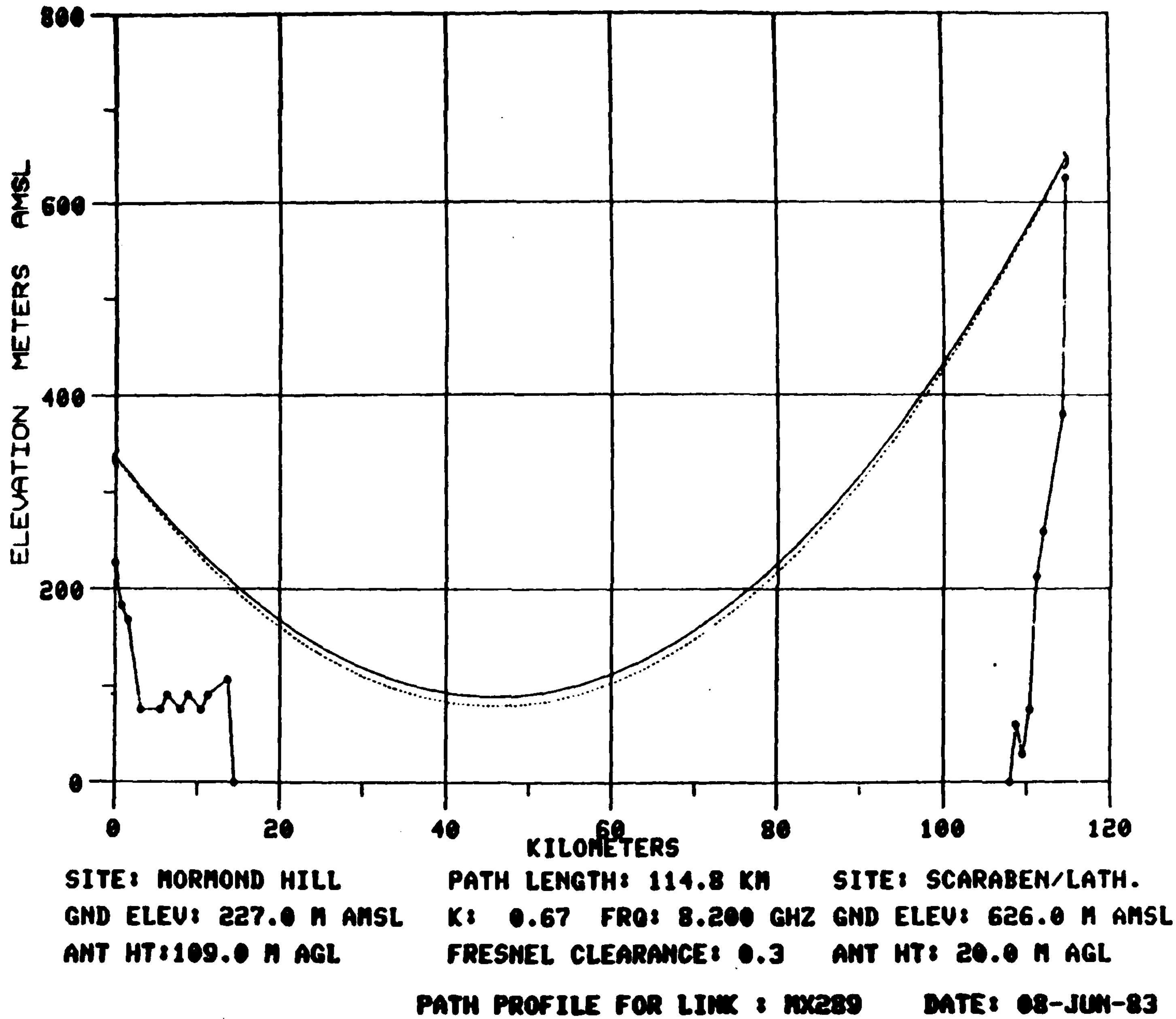


Figure 6. Path Profile for New Site at Scaraben

V. CONCLUSIONS

The impacts of various fading effects on performance of the Mormond Hill-Latheron radio link have been identified in this analysis. The severest degradations could be caused by partial or total traffic disruption due to inadequate path clearance during subrefractive propagation conditions. Collection of additional data in support of quantifying such disruptive occurrences is recommended prior to a final link configuration. An alternate repeater site location - Scaraben - was suggested in case the Latheron clearance proves inadequate.

The link performance analysis of this report provides the technical guidance needed for planning of a digital upgrade of the subject link. The recommendations for a link configuration using standard dual space diversity eliminates the need for utilization of the DIDICOM units in conjunction with a quad diversity configuration. The DIDICOM/Quad approach would be very wasteful in terms of cost, scheduling, logistical support, and performance.

REFERENCES

[1] DCEC TR 12-76, "DCS Digital Transmission System Performance," Kirk, K.W. and Osterholz, J.L., Nov 76.

[2] DCEC EP 27-77, "Design Objectives for DCS LOS Digital Radio Links," Parker D.E., Dec 77.

[3] DCEC TR 26-81, "Performance Analysis of Digital LOS Link Manila Embassy-Santa Rita, Philippines," Dec 81.

[4] Office of Telecommunications Report 75-59, "Refractivity Gradients in the Northern Hemisphere", Samson, C.A., Apr 75.

[5] NAVESEC, Wash, DC, "TEP for Link M0672 Latheron-Mormond Hill, Scotland," Oct 76.

[6] GTE Lenkurt, Inc., "Engineering Considerations for Mircrowave Communications Systems," Engineering Report, 75.

DISTRIBUTION LIST

STANDARD:

R100/R101 - 1
R103 - 1
R110 - 1
R120 - 1
R141 - 12
R200 - 1
R400 - 1
R600 - 1

R800 - 1
NCS-TS - 1
B100 - 1
B780 - 1
308C - 1
308 - 1
J700 - 1

DCA-EUR - 2 (Defense Communications Agency European Area
ATTN: Technical Library
APO New York 09131)

DCA-PAC - 1 (Commander
Defense Communications Agency Pacific Area
Wheeler AFB, HI 96854)

DCA SW PAC - 1 (Commander, DCA - Southwest Pacific Region
APO San Francisco 96274)

DCA NW PAC - 1 (Commander, DCA - Northwest Pacific Region
APO San Francisco 96328)

DCA KOREA - 1 (Chief, DCA - Korea Field Office
APO San Francisco 96301)

DCA-Okinawa - 1 (Chief, DCA - Okinawa Field Office
FPO Seattle 98773)

DCA-Guam - 1 (Chief, DCA - Guam Field Office
Box 141 NAVCAMS WESTPAC
FPO San Francisco 96630)

US NAV Shore EE PAC - 1 (U.S. Naval Shore Electronics Engineering
Activity Pacific, Box 130, ATTN: Code 420
Pearl Harbor, HI 96860)

USDCFO - 1 (Unclassified/Unlimited Distribution)
(Chief, USDCFO/US NATO
APO New York 09667)

DISTRIBUTION LIST (Cont'd)

SPECIAL: (as required)

PAC COMM DIV - 1
Hickam AFB, HI 96853

NAVTELCOM 62 - 5
Washington, DC 20390

NAV ELEC SYS COM PME 110-241
Washington, DC 20390

NAVCOMM AREA MASTER-MED - 1
FPO NY 09524

NAVCOMSTA THURSO UK - 2
FPO NY 09516

NAVSHORE ELEC ENG ACT - 1
FPO Seattle, WA 97862

NAVSHORE ELEC ENG ACT - 1
FPO San Francisco, CA 96630

NAVCOMMSYSTECH SCHOOL - 1
San Diego, CA 92133

NAVSHORE ELEC ENG ACT - PAC - 1
Pearl Harbor, HI 96860

ESD/TCFE - 1
Hanscom AFB, MA 01731

ECAC/CAA - 1
Annapolis, MD 21402

RADC/DCCT - 1
Griffiss AFB, NY 13441

CINCPAC/J6121 - 1
FPO San Francisco

END
FILMED
4-86
DTIC